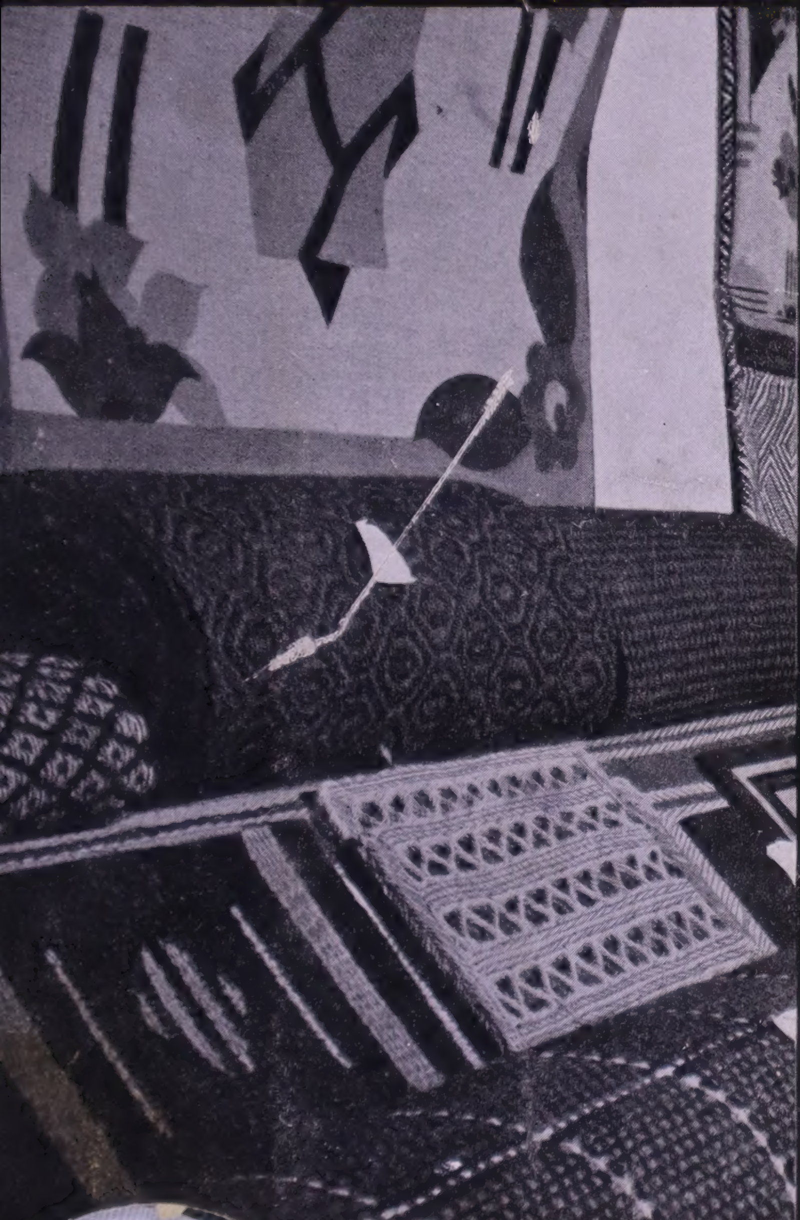
COIR

its extraction properties & uses



F SCIENTIFIC
STRIAL RESEARCH

NEW DELHI

COIR

Coir is an industrial fibre. It offers immense possibilities for profitable utilization on account of its natural resilience, durability, resistance to dampness, and other properties. It is extracted from coconut husks and is used for producing a variety of floor coverings such as matting, rugs and carpets. It is also used for cordage.

The present monograph fulfils the need for a consolidated account of the various aspects of coir technology, such as extraction of coir, spinning, weaving, dyeing and printing, production of ropes and cordages. Useful information on the structure and properties of coir fibre, and marketing and trade in coir and coir products have been included.

Rs. 6.00

Sh. 10/-

COCONUT TREE

COIR

Its Extraction, Properties & Uses

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
NEW DELHI

Printed by S. N. Guha Ray at Sree Saraswaty Press Ltd.,
32, Acharya Profulla Chandra Road, Calcutta-9

PREFACE

The All India Board of Technical Studies in Textile Technology realised as early as 1950 the need for a publication on Coir Technology and appointed three experts to collect material for the preparation of a monograph on the subject. The experts collected the information and prepared two notes on the subject.

At its meeting held in August 1953, the Board considered the two notes and decided that the information on all aspects of coir, such as processing, fibre structure and characteristics, grading, industrial uses and trade statistics, should be given in the publication and that the monograph should be appropriately prepared by the *Council of Scientific & Industrial Research*. The Council accepted the suggestion and compiled the necessary information for publication. The publishers acknowledge their thanks to the Board of Technical Studies in Textile Technology for initiating this publication and to the Coir Board for furnishing information and illustrations.

CONTENTS

1 Introduction

The word 'Coir' is derived from *kayar* which in Malayalam means a rope. The word seems to have been introduced into the European literature by Marco Polo, the Italian traveller, in the thirteenth century. Ropes of coconut fibre have been in use since ancient times and the term coir has come into use for designating the fibrous mass present between the outer husk and the shell of the inner kernel of the coconut. Coir, also known as Cocos Fibre, is classed among the industrial hard fibres which enter the world markets in the form of fibre, spun yarn or floor coverings.

Coir is in great demand on account of its natural resilience, durability, resistance to dampness and other properties. The important coir producing countries are India and Ceylon ; small quantities are reported to be produced in Pakistan. Coir is of special importance to the economy of the west coast of India and it is virtually a monopoly. Coir and coir goods annually account for Rs. 8 crores in India's foreign exchange.

The coir industry in India is basically a cottage industry, the various operations, such as collection of coconut husks, retting, extraction of fibre and spinning of yarn, being largely carried out by small units ; the extraction of fibre and spinning of yarn are almost entirely done in cottages. About 1,00,000 families on the Malabar coast are reported to be engaged in the industry. Coir mats and mattings are manufactured also in factories in Kerala ; about 15,000 workers are employed in this industry. Coir industrial co-operatives have been recently started for the manufacture of coir goods.

The Government of India passed the *Coir Industry Act* in 1953 with the object of coordinating the development of the industry in the several States of India. The Coir Board was established under the *Act* at Ernakulam and its objectives include: promotion of exports of coir yarn and coir products ; improvement of marketing methods ; formulation of qualilty standards, licensing of exports ; and encouragement of research.

A sum of Rs. 2.3 crores has been provided for the development of coir industry in the Second Plan. Out of this, Rs. 30 lakhs are allocated for Central Government schemes. The establishment of a *Central Coir Research Institute* and a pilot plant for the manufacture of coir products at Kalanoor (near Alleppey) and a Branch Research Institute with a model factory at Calcutta are among the steps taken by the Central Government for developing the coir industry.

Programmes for the development of coir industry on a cottage basis on the co-operative principle have been drawn up by all States. The co-operative organization in Kerala State provides financial assistance to small units in the various sectors of the industry. There are two Central Co-operative Marketing Societies in Kerala and a third co-operative has been recently organized to serve the needs of northern districts.

The *Coir Industry* (*Regulation & Licensing*) *Rules* were enacted in 1958. These rules are intended to regulate and control the export of coir products as well as to enable the Board to collect statistics relating to spindles and other necessary data.

2 Extraction of Coir

Coir is derived from the exocarp of the fruit of the coconut palm, *Cocos nucifera* Linn., which is widely cultivated in the tropics, particularly in India, Ceylon, Malaya, Indonesia, Philippines and the South Sea Islands. Some 30 varieties of the palm are reported in literature ; all of them can be classified broadly under two groups, the tall and the dwarf, each comprising a few varieties and forms distinguished by differences in size, number, colour and shape of fruits and bearing capacity of the palms. The palms commonly grown on a commercial scale in India and elsewhere are tall and stately, attaining a height of 80 ft. or more when fully mature bearing a crown of large pinnate leaves ; trunk stout, 1-1½ ft. diam., straight or gently curved, rising from a swollen base surrounded by a mass of roots ; leaves 6-18 ft. long, pinnatisect: leaflets 2-3 ft. long, narrow and tapering ; in the leaf axil is a spathe enclosing a spadix, 4-6 ft. long, stout, straw or orange-coloured and simply branched ; fruit ovoid, three-angled, 6-12 in. long, containing a single seed: exocarp (outer husk) thick and fibrous, enclosing a hard and bony endocarp (shell) ; adhering inside the endocarp is the testa with a thick albuminous endosperm (meat) ; the cavity of the endosperm is large and is filled, in the unripe fruit, with a watery fluid (coconut water): it is only partially filled in the ripe fruit.

The coconut plant thrives under a variety of soil, climatic and cultural conditions. It is hardy and long-lived (80 years or so) and begins to bear flower 5-6 years after planting under favourable conditions.

In India, the bulk of the acreage under coconut is concentrated in the coastal and deltaic regions of South India ; inland cultivation is by no means rare and large estates are situated far inland in Mysore State where favourable soil and climatic conditions prevail. Coconut is also cultivated in Orissa, West Bengal, Assam and in Andamans and Nicobar Islands. The area under coconut cultivation was estimated to be 10 lakh acres in 1955/56. Nearly 70 per cent of the total coconut area lies in Kerala (Table 1).

Coconuts are harvested only when they are fully mature, unless tender nuts are specially required. The yield of nuts in well-maintained plantations

TABLE 1—AREA UNDER COCONUT CULTIVATION & PRODUCTION OF COCONUTS IN 1955-56*

	AREA *acres*	PRODUCTION *thousand nuts*
Kerala	11,06,895	31,00,000
Mysore	2,18,100	4,99,345
Madras	1,27,221	4,17,453
Andhra Pradesh	87,990	2,33,009
Bombay	20,520	40,071
West Bengal	16,500	22,205
Orissa	11,085	32,576
Laccadive Islands	5,860	9,625
Assam	2,000	12,787
Andamans & Nicobar Islands	4,293	2,500
TOTAL	16,00,464	43,69,571

* Indian Central Coconut Committee (Provisional figures).

varies from 60 to 100 nuts per tree per year ; in indifferent and poorly cultivated fields, the yield may be 20 nuts or even less, per tree per year. Full yields are obtained when the palms are 7-15 years old ; and are sustained until the next 50-60 years.

The total production of coconuts in India was estimated at 43.69 lakhs in 1955/56. Of this, nearly 71 per cent was from Kerala. The production in Mysore was 11.4, in Madras 9.5 and in Andhra Pradesh 5.3 per cent.

India ranked first among the coconut producing countries of the world until 1921. Since then, the position has changed. Indonesia and Philippines have increased their production and India now occupies the second place. These three countries together account for nearly 65 per cent of the world production (17,000 million coconuts) out of which India's share is 25 per cent.

Ripe coconuts are used for local domestic consumption and for religious offerings. The shredded and dried kernel is the desiccated coconut of commerce. Coconuts are mainly used for the production of copra from which coconut oil and coconut cake are obtained. Coir is extracted from the husks of the whole coconut.

For obtaining coir fibre of commercial value, coconuts must have grown for 6-8 months reckoning from the time of nut formation. This degree of maturity is also considered sufficient for oil formation in the kernel. Under

favourable conditions, coconuts can be harvested once in 45 days although in some areas they are harvested once in 60 days. Immature and over-mature nuts yield fibre of poor quality.

Dehusking

For extracting the fibre, the first step is the removal of husk from the nut. It is usually done by ramming the coconut against a wooden or iron spike fixed to the ground and splitting the husk into three or four pieces (Fig. 1).

The extraction of fibre from the husks involves the following operations: Retting, cleaning, drying and combing.

Retting

The separation of fibre from the husk is effected by retting, which consists essentially of soaking the husk in water for several weeks. The process varies from place to place, according to local conditions. In the common method of retting, known as 'pit retting', the husks are buried in basin-shaped pits dug on the banks of backwaters and the ebb and flow of water at the top and free percolation of subsoil water from below provide the necessary water movement. Alternatively, the pits are provided with channels to allow water to flow in and out with the rise and fall of the tide. The bottoms of pits are covered with sand and the sides are lined with coconut leaves. After charging, the pits are covered with coconut leaves and weighted

FIG. 1—DEHUSKING OF COCONUTS

down with mud to prevent the husks from floating when water is admitted. As many as 20,000 to 30,000 husks are placed in each pit. The pits are opened after the completion of retting and the mass is treated for separating the fibre.

In Anjengo and Ponnani areas of Kerala State, where the best quality of coir is produced, retting is carried out by placing the husks (*c.* 10,000) in coir nets called *vallies* and transferring them to brackish backwaters subjected to tidal action. The husks are kept floating for a few days and then immersed by weighting with mud and stones. The retting period ranges from 6 to 9 months after which the mass is taken out for further treatment.

A third method is to prepare enclosures in shallow backwaters with stakes and coconut leaves, and put the husks inside the enclosures. The husks are covered with coconut leaves and weighted down with mud.

In localities with no backwaters nearby, retting is effected by either burying the husks in sandy soils or by immersing them in pools of water for short periods (a few days to a few weeks). The husks so treated are known as soaked husks. This method is in vogue in some parts of Kerala and West Bengal.

Coir is sometimes extracted from dry husks after immersing in water for about 12 hr and beating out the fibre. A considerable quantity of green or raw husk is utilized in Kerala for extracting fibre without retting or soaking. The fibre obtained in this way is inferior and is known as 'unsoaked' coir.

In Andhra, soaking is done in large pots for about 24 hr. Fibre suitable for making brushes, upholstery, etc. is obtained from soaked husks.

The retting operation is mainly biological and is based upon the differences that exist in the susceptibility to rot or microbiological decay of the different constituents of the husk. It involves the use of living organisms adventitiously present in the retting atmosphere, in exerting their degrading action upon the particular tissues which are intended to be preferentially destroyed. The process is usually anaerobic but retting can also be carried out under aerobic conditions. However, the fibres extracted by the latter process are likely to be badly coloured owing to the oxidative nature of the phenolic constituents of the husk and the insoluble nature of the products of oxidation. The sequence of changes involved in biological retting are not fully known.

The retting process employed in India is anaerobic. During the first few days of retting, the water gets distinctly brown because of the changes brought

about by atmospheric oxygen on the extracted materials from the husk. As the biological action proceeds, the retting liquor becomes increasingly milky for about a month, at the close of which a scum appears on the surface. This is followed by a sharp rise in temperature of the mass of husks, accompanied by frequent liberation of pungent smelling bubbles of hydrogen sulphide. These activities increase from the third to the fifth month and soon after the sixth month the water clears and the liberation of gas bubbles and the foul odour diminish. A major part of the husk gets softened at this stage and the separation of fibre is possible with the exception of the hard tips and the inner layers of the exocarp, which require ten months or even more for a satisfactory ret.

The possibility of producing sulphur from retting grounds has been examined by Warrier and Pandalai and they are of the opinion that the retting grounds would be a source of some quantity of sulphur[31].

Research on retting of coir was initiated in India by Fowler and Marsden[18] in 1924. Their investigations showed that preliminary crushing of husks before retting reduces the retting period to a considerable extent. Husks are soaked in pits or enclosures in the usual way until bacterial action sets in. They are then withdrawn and crushed by passage between fluted rollers and returned to the pits for completing the retting. Laboratory studies showed that a period of 5 weeks is sufficient, a period of 3 weeks is considered sufficient in commercial operation. More recent work by Pandalai *et al.*[34] indicates that microbiological action takes place quickly and efficiently only in brackish or saline waters.

The factors affecting retting, such as the condition of husks, the nature of water, the season, and the means employed for keeping the husk under water, have been studied. Fresh husks treated within a few days after their separation from nuts give better fibre than dry husks. Husks retted in saline backwater yield stronger and better coloured fibre than those retted in fresh water. Retting is quicker in fresh water but is generally incomplete and the fibre retains a certain amount of pith. When retting is done in stagnant water, the fibre obtained is weak and of a dull colour. Retting is quicker in summer months, but the colour of fibre extracted is brown. Husks soaked in shallow backwaters give better fibre than those retted in deep water. Husks placed in coir nets and sunk in backwaters give better fibre than those retted in pits.

A quicker method of retting has been developed by Baruah and Baruah[8]. A mixture of enzymes extracted from the mould, *Thielaviopsis paradoxa* (De Seynes) V. Hohn, Hiparol, is added to the retting tank to accelerate the degradation of non-fibrous binding materials.

A process of chemical retting of coconut husks has been worked out by Barker[7]. The fibre obtained is of inferior colour.

Many attempts have been made to find alternative methods to retting by steeping in water. None of these has been adopted on a large scale. In the Nanji process, partially crushed husks are treated with lime, sodium sulphate or sodium carbonate and subjected to steam at a pressure of 80-100 lb./sq. in. for a couple of hours, followed by drying and willowing. In the Elod process, the husks are immersed in hot water for a short period ; the husks are then spliced and again immersed in water containing alkaline substances and treated mechanically. In the Rowell process, the compact mass of husks is subjected, in a specially constructed chamber, to steam pressure up to 800-900 lb./sq. in. and the loosened fibres are extracted under pressure. In another process by Vander Jagt, crushed husks are boiled in a weak solution of caustic soda and then opened out by picker cards. They are then passed through fluted squeeze rollers, softened, washed and opened. Hayes-Gratze splices the husks by special machinery after soaking them in water followed by squeezing and washing in hot water ; the fibrous mass is then passed through an oil emulsion and boiled for 1-4 hr and intermittently pressed and rubbed by special machinery till the fibres get separated. The principle of disintegration by impact is applied in the method developed by *E. W. Downs & Sons* (*Tropical*) *Ltd.*, England. A fully mechanical process has been described by Glade. These processes have been reviewed by Prabhu[39,40].

Mechano-chemical Process

A mechano-chemical process for the production of white coir fibre has recently been developed in England[12]. The husks are opened up in a husk burster and passed into a sifter for separating the dust. The fibre is fed into a tank containing an aqueous solution of tannin extracting agents at the boiling temperature and stirred for 15 min. It is then washed with water and the wet fibre processed in a turbo screen which opens up the fibres. For spinning purposes, the fibre is transferred to a separator running in conjunction with a turbo screen in which fibres too short for spinning are separated out. The processed fibre can be spun and dyed in light shades. The dust obtained is used as fuel ; the ash is rich in potash and is useful as a fertilizer.

Another mechano-chemical process for coir extraction has been developed by a combination of Dutch manufacturers, *Cocos-Conventie*[24]. Utilizing the process, fibre and yarn of superior qualities have been obtained from coconuts available in Mombasa.

Separation of Fibre

Retted husks are rinsed with water and the pericarp and inner short fibres, called 'nose fibre', are removed by hand. The husk is then placed on a flat

piece of wood or stone and beaten with a wooden club or mallet usually made from tamarind heartwood. The decomposed pithy matter separates out and the fibres are collected. The process is laborious and an adult woman worker can handle about 45 husks in a day. The fibre adhering to the outer skin is harsh and thick and is not suitable for weaving.

The fibres are cleaned, dried in shade and beaten lightly with rattan sticks to remove adhering pith, if any, and also to free the fibre from entanglement ; at a few places, beating machines are used. The fibre is then dried in shade. Fibres of good quality are sometimes passed through a specially designed hand-driven comber or willowing machine to separate adhering pith and also to remove knots. The machine consists of a drum with an iron shaft carrying a number of flat toothed blades which pass through a set of teeth fixed at the top and bottom of the drum within. The fibres are fed by hand at one end and the shaft is rotated at high speed. The blades take up the fibres and as they pass through the grid in the upper part of the machine, the adhering particles are scraped off ; also the fibres are straightened, smoothened, and laid parallel to each other.

There are in all 5,667 willowing machines in Kerala State, out of which 53 per cent are in Trivandrum district, 45 per cent in Quilon district and 2 per cent in Trichur district[42].

Production

The average yield of fibre is 1 candy (672 lb.) from 3,500-4,000 nuts. A yield of 1 cwt. of clean fibre from 600 nuts is reported from Malabar. The recorded yield of bristle fibre in Ceylon is 250-300 lb. per 1,000 nuts.

Out of 4,370 million husks produced in India annually, hardly 50 per cent is utilized for coir production. Except in Kerala, little use is made of husks in other States. About 80 per cent of the available husks in Kerala is turned into coir.

Reliable data relating to the production of coir fibre in the country are not available. Being a cottage industry spread over a wide area, only estimates of production are possible. The Panel on Coir[43] estimated the annual production of coir during pre-war years at 122,326 tons ; the break-up of production according to producing areas was reported to be as follows: Madras, 25,038 ; Travancore, 80,000 ; Cochin, 17,000 ; and Bengal, 225 tons. The production declined during World War II owing to the closing down of normal markets, shortage of labour and uneconomic returns. There has since been a revival. The *Ad hoc* Committee for Internal Marketing, appointed by the Coir Board, estimates the present production of coir yarn at 120,000 tons per year ; assuming a wastage of 10 per cent in spinning and manufacturing processes, the Committee estimates the annual production of coir fibre at 130,000 tons.

Three classes of fibre are recognised in the trade. They are Mat, Curl (toe or mattress), and Bristle fibre. The bulk of fibre produced on the West Coast of India is mat. Mat fibre is sometimes used as a substitute for hemp in certain cordages. Curl fibre is obtained mostly from unretted husk and is short ; it is used for mattresses or for stuffing upholstery, cushions, etc. Bristle fibre, which is coarse and thick, is used for making brushes and brooms. It is not produced in India but imported from Ceylon. The quantity of bristle fibre imported into India during 1955 and 1956 was 9 and 8 tons respectively. It is proposed to set up a factory as an adjunct to the *Coir Research Institute*, Calcutta, to study processes of manufacturing hard bristle fibre.

Packing

Cleaned fibre is tied into bundles. The weight of bundles at different producing centres is generally so arranged that 10 bundles make one candy (6 cwt.) *plus* the extra weight allowed for drying. Fibre for export is pressed into bales of 200 lb. each. Bales of bristle fibre imported from Ceylon usually weigh 2 cwt.

Bristle & Mattress Fibres[5]

Retting. Bristle and mattress fibres are produced in Negombo area in Ceylon. The retting process employed is somewhat different from that used in India. In the area north and south of Galle, coir fibre for spinning is produced by retting husks in salt water in very much the same way, as on the Malabar coast, except that the duration of retting is somewhat short.

Retting and fibre extraction in Ceylon are mostly done on a factory basis in fibre mills. The husks are usually crushed before retting. The crushing machine consists of a chute leading into a pair of rotating fluted iron rollers set just wide enough to grip the husk and crack the exocarp without seriously damaging the fibrous matter. This treatment considerably reduces the retting period.

Retting is carried out in stagnant water, more usually in specially dug pits, capable of retting 1,00,000 to 2,00,000 husks ; a few are large enough to handle 10,00,000 husks. Retting takes 3 to 6 weeks according to the position of the husks in the pit, those which are completely submerged require a shorter period than those on the surface. Modern mills employ concrete tanks (*c.* 27 ft. × 9 ft. × 6 ft.) usually built in a series ; the construction permits frequent changes of water. Pressure is applied on husks by means of girders fixed in walls just below the water level ; sometimes, heavy logs are placed on the husks and held in position by chains. Retting of uncrushed husks takes 7-10 days ; crushed husks need 3-7 days. The colour of tank-retted fibre is better than that of pit-retted fibre.

Decortication or Milling. Fibre from retted husks is extracted in specially constructed drums, arranged in pairs, and known as breaker drum and cleaning drum. Each contains a wooden wheel 90 cm. in diam. with treads about 30 cm. wide and 15 cm. long into which iron nails are bolted at distance of 3.8-5.1 cm. apart, each tread carrying about 30 nails. The crushing drum carries 1,200 nails and the cleaning drum 1,350 nails. As the crushing drum revolves, the operator holds one end of the husk and forces the other end between two iron bars so that the exocarp surface is pressed against the nails. The nails tear away the exocarp, short fibres, and connective tissue leaving only the long fibres. The process is repeated by reversing the husk. The fibres are bundled and the treatment repeated in the cleaning drum with finer nails ; short fibres are thereby combed out.

The bristle fibre is washed in fresh water and laid out to dry. Dried fibre is hackled by drawing through a set of steel spikes 10-15 cm. long and 2.5 cm. apart, fixed vertically on a table when a further quantity of short fibre and bits of adhering matter are removed. Hackled fibre is tied into hanks, each weighing about 0.45 kg. Twenty-five to thirty hanks are tied together to a bundle and sent to shippers. In some mills, bristle fibre is not subjected to hackling, but sold as 'unhackled one-tie bristle fibre'.

The fibre is bleached in sulphur smoke in sealed rooms for about 24 hr to obtain a product of uniform golden colour.

The fibre is sometimes dyed black and drafted. Drafting is a form of super-hackling and grading according to fibre length. Drafted fibre is packed in bales of about 3 cwt. Hanks are laid horizontally in a steel box about 12 ft. high and hydraulically pressed, hooped, and sewn up in jute hessian.

Mattress Fibre. The fibrous material, pith and hard pieces of exocarp removed by the breaker drum are carried to a rotating cone-shaped sifting machine containing stout wire netting (mesh, *c.* 3.8 cm.). This sieve removes some short fibres, much of the pithy matter and mud particles and the sifted fibre is discharged.

The fibre is then transferred to a 'teaser'. The teaser is a rectangular box containing wire mesh at the bottom. The fibre is subjected to vigorous mechanical beating so that whatever vegetable matter that adhered to it is separated.

The thoroughly cleaned fibre is then spread out on the ground and dried in the sun.

The fibre is packed by hand-operated presses into small bales, known as ballots, each containing approximately 5 kg. of fibre.

The shippers break up the fibre ballots, clean the fibre, weigh it in 51 kg. lots and bale it. Each bale generally weighs 153 kg. Each bale varies in capacity from 0.28-0.34 cu. m. Mattress fibre can be obtained in the twisted rope form but the demand is very small. It is claimed that the product is more resilient than the material in baled form.

3 Structure & Properties of Fibre

The ultimate coir fibre is polygonal to round or oblong in section with blunt or rounded ends. The cell wall is thin to fairly thick with lens-shaped silicified stegmata ; delicate reticulate thickenings and a few annular or spiral thickenings are also present. Individual fibres are 0.3-1.0 mm. (av. 0.7 mm.) long and 0.010-0.024 mm. (av. 0.020 mm.) in diam.[21] ; the ratio of length to diam. is 35. The lumen is medium to large, polygonal-rounded, rounded or elliptic. The vascular bundle is collateral and is surrounded by a thick sclerenchymatous sheath ; the cross-section is hemiconcentric. Lignins and hemi-celluloses, which form the cementing materials of fibre cells, increase with the age of the fibre and pectins decrease. As the lignin content increases, the fibre becomes stiffer and tougher.

Sen Gupta *et al.* have given an account of the structure of coir fibre[16]. Distinct wavy outline of the edges of the ultimate fibre and round stegmata to be found in the ash are particularly characteristic (Fig. 2).

The fibre sinks in 92 per cent alcohol but floats in methyl salicylate[7]. The colour reactions of the fibre with various reagents are listed in Table 2.

The utility of coir fibre is determined principally by its physical properties, e.g. length, fineness, strength, elongation, elastic recovery, Young's modulus and rigidity modulus.

Physical Properties

Length. This is one of the important properties of the fibre which determines its spinnability and commercial utility. Spinnability may be defined as the ease with which textile fibres may be twisted into continuous, uniform yarns, having commercially acceptable properties. These requirements are to a great extent met by long fibres of good fineness and strength, though other factors like rigidity, clinging power, etc., are also to be taken into account in assessing spinning quality.

Coir fibres vary widely in length as is usual with natural fibres. Hence,

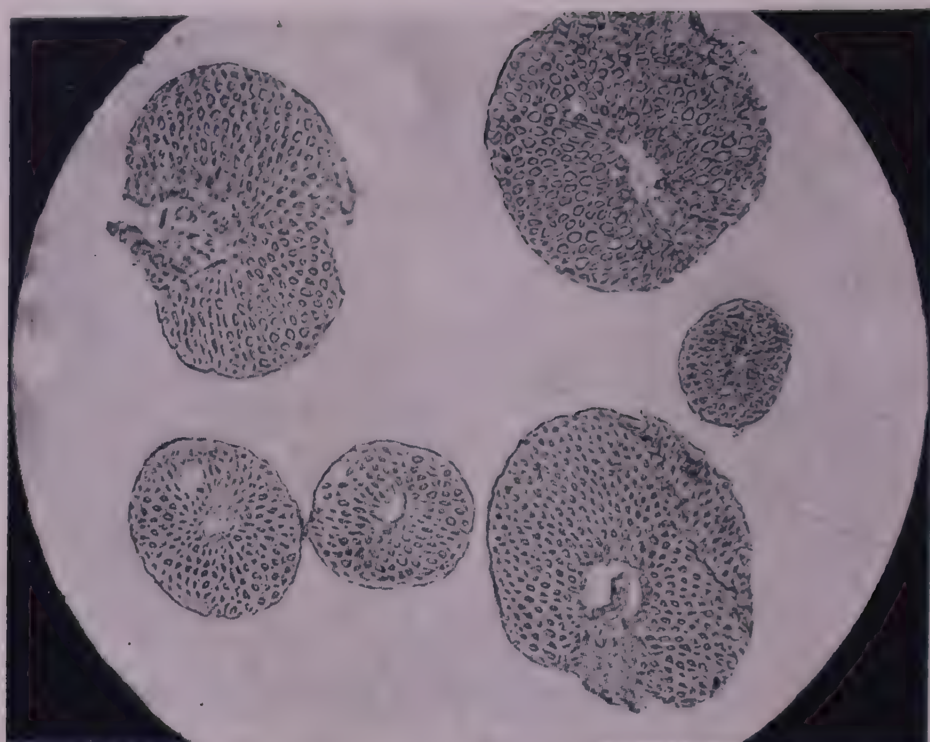


FIG. 2—CROSS-SECTION OF COIR FIBRE (× 200)

besides average length of the fibre, the evenness of the staple or length distribution of the fibres is a very important criterion.

Prabhu[35] has examined the length distribution of coir fibres grouped into four grades: long, FFFF (6 in. and above) ; medium FFF (4-6 in.) ; short, FF (2-4 in.) ; and very short, F (2 in.) according to the grades assigned in accordance with the boxed colour standards of the Indian Standards Institution. Table 3 gives length distribution of different grades of coir fibre.

Fineness. The fineness of a fibre is usually expressed by its diameter in microns or by the weight of the fibre per unit length-denier. The compactness and strength of a yarn or cord depends to a great extent on the cohesion between individual fibres, which is governed by the fibre to fibre contact between component units. This is to a considerable extent dependent upon the surface area of the fibre. The smaller the diameter of the fibre, the larger is its surface area per unit weight.

Fibre width is measured with the help of a microscope at different points of fibre and statistical analysis of the value is made to ascertain the degree of variance.

Strength. The development of fibre strength is important for the production of yarns and fabrics which are required for specific purposes, e.g. cords and ropes which must stand stretch, pulls and shocks. The tensile strength of a fibre is determined by its ability to resist strain or rupture induced by

tension, and is a determining factor in the selection of a fibre for any given purpose. It is expressed as the breaking load per unit area of cross-section of the test specimen.

As the shape of the fibre varies at different points of the fibre, it is difficult to compute the cross-sectional area at the point of rupture ; the breaking load is often expressed as the force denier fibre weight per unit length. This is termed as tenacity of the fibre.

Elongation. Elongation at rupture is a criterion of practical value and is an index of the work that could be performed by the fibre within the limits of its breaking load. The elongation is expressed as a percentage of the original length of the test specimen.

Torsional Rigidity. Stresses in the fibre due to twisting and bending are important factors which affect the diameter of the yarn, its liability to snarl,

TABLE 2—COLOUR REACTIONS OF COIR FIBRE

Reagent	Colour
Phloroglucinol reagent*	Pink
Aniline sulphate	Yellow
Methylene blue, basic fuchsin & acetic acid	Deep purple
Swett's test	Brown
Shirlastain A	Mottled brown & blue
Shirlastain C	Green
Texchrome	Pale yellow
Lowe's reagent & picric acid	No change
Iodine and sulphuric acid	Golden yellow

* 2 per cent alcoholic solution of phloroglucinol & equal vol. of con. hydrochloric acid.

TABLE 3—LENGTH DISTRIBUTION OF DIFFERENT GRADES OF COIR (AVERAGE PERCENTAGE)[36]

Grade*	Long fibres	Medium fibres	Short fibres	Very short fibres
FFFF	65.43	17.41	12.03	5.13
FFF	62.01	20.13	13.87	3.99
FF	57.88	20.75	15.29	6.08
F	55.99	21.08	15.07	7.86

* Grades assigned according to boxed colour standards of Indian Standards Institution.

its pliability and elastic recovery from small strains and internal pressures which give strength to the yarn.

The most useful measure of this property is the twisting force developed when one centimeter length of the fibre is given one complete twist. Prabhu has determined the rigidity modulus of coir fibre by the torsion pendulum method. Table 4 gives the physical properties of coir as determined by Prabhu[36]. Prabhu[39] also carried out comparative studies on delignifying, softening and bleaching of coir fibre and their effect on tensile strength, colour and feel.

Mathai, Variar and Moudgil[27] have also determined the tensile strength of the fibre. A standard test method for torsional rigidity is being developed and investigations on the resistance of fibre to bending are in progress at the *Central Coir Research Institute*.

The fibre has a spiral angle (angle between the direction of fibrils in the cell wall and the fibre axis) of 45° and is sufficiently large to be measured by X-ray diagrams[21]. X-ray photographs of fibres isolated from green and dried coconuts are similar and crystallites of cellulose in both types of fibres are oriented at the same spiral angle to the fibre axis[6].

Whereas most textile fibres possess positive birefringence (that is, the refractive index along the fibre is greater than that across the fibre) coir fibre shows a negative birefringence[23].

The high extensibility, initial Young's modulus and other viscoelastic properties of coir can be qualitatively explained on the basis of tensile deformation of its helical structure (that is, changes in spiral angle during stretching). Coir fibre does not show any fluorescence under ultraviolet light.

Table 5 gives the physical characteristics of coir fibre as given by Meredith[32]. The characteristics of some common fibres are also given for comparison.

Chemical Composition

Coir is a cellulose-lignin complex. It burns very slowly and emits copious yellowish white fumes. The ash is grey in colour. The chemical composition of coconut husk and coir fibre is given in Table 6.

Grading

Coir fibre is classified into four grades. The best fibre, free from piths, is usually termed Cochin Fibre ; next comes Lustrous Fibre, followed by Reddish or Greyish fibre containing some pith ; fibre of inferior quality is dark in colour and contains pith. A tentative specification (IS: 898-1957)

TABLE 4—PHYSICAL PROPERTIES OF COIR (GRADE FFFF)[38]

	No. of fibres tested	Standard deviation	Mean value†	Coeff. variation	Av. value
Fibre width, μ	299	10.8490	20.7532	52.28	222
Tenacity, g./denier	1200 (in 59 groups)	0.2063	1.3286	15.52	1.3286
Elongation, %	1194	2.3225	7.3777	31.48	29.04
Rigidity modulus, dynes/sq. cm.	269	1.4140	1.8924	74.71	1.8924

† arbitrary units

TABLE 5—PHYSICAL PROPERTIES OF COIR FIBRE§

	Specific strength* *kms wt*	Elongation† at break %	Toughness‡ *kms wt*	Initial Young's modulus@ *kms wt*
Coir	18	16	1.6	430
Cotton	32	8	1.2	500
Flax	55	3	0.9	1800
Kapok	16	1.2	0.1	13
Viscose rayon	19	21	2.3	600

§ Kaswell, E. R., Textile Fibres, Yarns & Fabrics (Reinhold Publishing Corp., New York), 1953, 25.
* Specific strength (kms wt)=breaking load (g. wt)/fineness (μg./cm.) for 1 cm. test length loaded at 1½ km. wt per sec.; † extension at break, %=100×extension at break/original length. Same conditions as for strength; ‡ toughness (kms wt)=energy per unit mass to rupture, the fibre=area under the stress-strain curve; @ initial Young's Modulus (kms wt)=resistance to extension=load fineness/extension/unit length.

for coir fibre prescribes the requirements for four grades based on colour (Table 7).

Bristle fibre produced in Ceylon is graded at the shipper's stores according to length, toughness and colour and made into hanks, each weighing 0.5 kg. Hanks are tied by 3, 2 or 1 twisted fibre cords according to grade. The commonest quality is known as One Tie. Superior grades are subjected to hackling and fibres of long staple (*c.* 12 in. long) of good colour are tied into bundles with three cords and marked 3 Tie or Best Quality. The intermediate grade is bound with two cords and known in trade as 2 Tie.

Mattress fibre is graded on the basis of colour, fibre length, resilience and general cleanliness, especially the quantity of pith present. The best grade

mattress fibre known as No. 1 in the trade is of a fine golden colour. The next grade known as Fair Average Quality (F.A.Q.) is duller in colour and has less "life" in it, while the lowest grade known as No. 2 is dark in colour. The shipper prefers a bale fibre with moisture content of 12-14 per cent.

Deterioration of Fibre

The comparative extent of fungal and bacterial degradation of a number of cellulose fibres has been studied by Bose[11]. Of these, coir has been found to be remarkably resistant to both fungal and bacterial decomposition.

Deterioration of coir is brought about by chemical and biological factors. Chemical tendering usually takes place as a result of accidental contact with acids, alkalies or other chemicals during storage or transit, or when coir is subjected to weathering. Biological tendering is due to microorganisms,

TABLE 6—PERCENTAGE COMPOSITION OF COCONUT HUSK & COIR FIBRE (DRY WT. BASIS)*

	Total water-solubles	Pectins, etc. soluble in boiling water	Hemi-celluloses	Lignin	Cellulose
Husk from old nuts	26.00	14.25	8.50	29.23	23.87
Husk from young nuts	29.00	14.85	8.15	31.64	19.25
Husk from very young nuts	38.50	15.25	9.00	20.13	14.39
Fibre from old nuts	5.25	3.00	0.25	45.84	43.44
Fibre from young nuts	16.00	2.75	0.15	40.52	32.86
Fibre from very young nuts	15.50	4.00	0.25	41.02	36.11

* Ciba Rev., **116** (1956), 31.

TABLE 7—ISI SPECIFICATIONS FOR COIR FIBRE*

Grade	Colour**	Maximum impurities %	Proportion of long, medium & short fibres
1	White and/or bright natural	2.0	Long, at least 70% by wt.
2	Natural and/or light red and/or light grey	3.0	Long, at least 50% by wt.
3	Reddish and/or greyish	5.0	Medium, at least 80% by wt.
4	Dark red and/or dark grey	7.0	Medium and/or long, at least 20% by wt.

Ash content of various grades shall not exceed 40% ; moisture content shall not exceed 15%.
* IS : 898-1957

** Colour judged by comparison with the replica of Boxed Coir Colour Standards held in custody by Coir Board, Indian Standards Institution, etc.

especially when coir comes into contact with soil or is contaminated with materials which act as nutrients for microorganisms[46].

Well-known chemical methods applicable for the identification of tendering in cotton and other cellulose fibres are not applicable to coir. A procedure has been evolved for distinguishing different types of chemical and biological deterioration of coir[46].

4 Spinning

Spinning of coir yarn is mainly a cottage industry. About 75 per cent of the yarn is produced by farmers who purchase retted husks from nearby centres ; a few undertake retting or soaking operations themselves. Coir yarn is also produced by a few large scale producers.

The bulk of coir yarn (*c.* 80 per cent) is produced by wheel spinning ; it is produced also by hand spinning in Malabar.

Wheel Spinning

Two wheels, one stationary and the other movable, are employed in wheel spinning. The stationary wheel, which is generally fixed to the ground, contains two spindles which are set in motion by rotating a central wheel by means of a handle inserted through its centre. The movable wheel contains one spindle and is mounted on three smaller wheels so that it can be moved forward and backward. A group of three workers is required for spinning, one to handle the stationary wheel and two to make the strands which make up the two-ply yarn. Slivers are taken by two persons, who, keeping them in their arm pits, make a loop with a small quantity of fibre. Each worker then puts the loop into the notch of one of the spindles of the stationary wheel and gives the sliver a uniform thickness. The third worker rotates the wheel to give the necessary twist. As the wheel is rotated the two spinners deliver the fibre in the required thickness, walking backward till the required length of strand is reached. The fixed wheel is then stopped and the two strands are passed through grooves on the sides of a triangular block of wood and tied together to the notch of the single spindle of the movable wheel, which is then gently rotated to give a twist in the opposite direction to the two-strand yarn, while one of the spinners moves with the grooved wooden block towards the stationary wheel. As the yarn is being made, the wheel is moved towards the fixed wheel. The grooved wooden block regulates the counter-twist, prevents entanglement of strands at the time of twisting and binds the strands close. The spun yarn is reeled into hanks of 50-60 ft. (15-18 m.) in length. Three workers produce on an average from 11 to 33 lb. (5-15 kg.) of yarn per day.

Hand-Spinning

In hand-spinning, the fibre is rolled between the palms with a clockwise twist into short length threads (15-23 cm.). When of sufficient length, the threads are taken in twos and twisted together in the opposite direction to form a strand of yarn. The spun yarn is held in position by toes while further pieces of short length are added one after the other and counter-twisting by hand is continued till the required length of yarn for a knot (20-60 ft. or 6-18 m.) is reached. The yarn is then reeled in the form of a hank and a knot made at the end. One worker produces 4 to 5 lb. (1.8-2.2 kg.) of yarn per day. Combed fibre is not used for hand spinning.

Mechanized Spinning

No power machine has been used so far for spinning in India. The Coir Board is sponsoring a treadle operated machine which produces a yarn, less hairy, more regular in twist and of longer continuous length than yarn spun on spinning wheels used at present. The machine can be operated indoors and requires less space (Fig. 3).

FIG. 3—TREADLE-OPERATED COIR SPINNING MACHINE

Classification of Yarn

Hand-spun yarn is soft and the twist and thickness are even. Wheel-spun yarn has a hard twist ; it is stronger and more uniform in size and twist than hand-spun yarn.

The quality of yarn is judged by the thickness, colour, appearance, uniformity in twist, strength, fineness, texture, and freedom from impurities. The fineness of the yarn is designated by 'score', which is the length of a defined weight of yarn, and is expressed in standard hanks per pound of yarn. Coarse yarn has a lower score in comparison to fine yarn. Another method of determining the score is to divide by 20 the number of warp yarns required for preparing matting 3 ft. wide ; for example, the score of yarn for producing matting 3 ft. wide with 260 warp yarns is 13, that for making one with 300 warp yarns is 15.

The classification of coir yarn is based on variations of colour, twist, pitch, scorage, etc. and also area of production. Variations are due to differences in methods and conditions of retting, methods of spinning, seasonal conditions, etc. obtaining in different areas. Yarns are accordingly named after

TABLE 8—PRODUCTION OF COIR YARN IN KERALA*

Type	Qty (tons)
Anjengo	40,000
Mangadan	16,000
Aratory	9,000
Alapat	1,000
Ashtamudy	3,000
Vycome	14,000
Beach	2,500
Rope yarn	2,000
Medium rope	1,000
Parur	4,000
MK & SMK yarn	1,000
Beypore & Quilandy	26,000
Muppiri	100
Total	119,600

* Rep. Ad-hoc Committee for Coir Yarn (Coir Board, Ernakulam), 1955, app. III.

the places of production, for example, Anjengo yarn, Vycome yarn, etc. The place names have come to be associated with definite characteristics, so much so, that a yarn conforming to the characteristics of Anjengo yarn, no matter where it is made, is called Anjengo yarn. Table 8 gives the different types of coir yarn produced in Kerala. The varieties common in Kozhikode and Ponnani markets are Kadalundi, Ponnani, Chowghat, Ariyalur, Kallai, and Parapangadi, all hand-spun. The most important types of wheel-spun yarns are Anjengo, Aratory and Ashtamudy. Alapat and Beach are the best known among hand-spun yarns.

Anjengo and Mangadan yarns of superior quality are hard-twisted and evenly spun, of smooth texture, with bright natural colour. Ordinary Anjengo is thick and somewhat rough and hairy. Superior Aratory is a clean white yarn of hard, but not very regular twist ; it is more hairy than superior Anjengo. Real Alapat yarn is a hand-spun, soft-twisted, evenly spun yarn of bright butter colour. Ashtamudy (or Carruva) is a yarn of medium and even twist and good tensile strength, but somewhat hairy in the lower grades. Good Ashtamudy yarn is occasionally traded under the name of 'Imitation Alapat' on account of its resemblance in twist to real Alapat yarn (Fig. 4).

Medium Vycome is a loosely spun yarn, rather fluffy and uneven, but of good colour. Formerly it was made exclusively by hand-spinning ; it is now produced on spinning wheels.

FIG. 4—DIFFERENT TYPES OF COIR YARN IN BUNDLES

Beach yarn, produced from imperfectly retted husks, is of low grade ; it contains a large quantity of pitch and is reddish brown in colour. Its tensile strength is also low. Cochin yarn is somewhat coarse and is mostly exported. About 40-50 per cent of the yarn produced in Cochin is rope yarn. Rope yarn (roping) is a thick, heavy, soft-twisted yarn, and is invariably hand-made.

Quilandy yarn is the thinnest and the most regular among Calicut varieties. Ashtamudy is similar to Quilandy in twist and texture, but is greyish in colour and is mostly hand-spun. Beypore yarn is thick, regular and of good colour.

Unsoaked yarn is subdivided into a range of qualities differing mainly in colour and cleanliness. It is characterized by looseness of twist, contains a fair amount of pith and ranges in colour from creamy buff to dark reddish brown. It is exclusively hand-spun.

Information on the more important centres of coir production and uses of different types of coir yarn is summarised in Table 9. The superior types are further classified into grades according to fineness and evenness of twist as judged by visual examination. Each of these grades is further subdivided into two or three grades distinguished as A, B, C or No. 1, No. 2, etc. according to colour. Yarns of bright golden colour are considered to be superior. Cheaper types are classified into grades distinguished by numbers 1, 2, 3, 4, etc. according to colour, evenness of twist and pith content.

The results of a survey and assessment of different commercial types and qualities of yarn, in measurable terms, carried out by the Agricultural Marketing Department of the Government of India in 1943, are given in Table 10.

Ceylon yarn is sold in two grades, Kogalla and Colombo, with sub-divisions according to texture and thickness. Superior grades are further classified according to fineness and evenness of twist and sub-divided according to colour into 2 or 3 grades. Cheaper types are sub-divided into grades denoted by numbers according to their colour, evenness of twist and amount of pith.

Production

The output of spindle-spun yarn in 1955 was 59,332 tons in Travancore-Cochin and 1,640 tons in Malabar, totalling 60,978 tons. Table 11 gives break-up figures for different types of yarn. About, 9,000 tons may be added to the recorded total of 60,978 tons for omissions and under-declarations. The production of hand-spun yarn has been estimated at 36,000 tons. This gives a total production of 106,000 tons of yarn in 1955. The *Ad hoc* Committee for Internal Marketing of the Coir Board estimates the total production at 120,000 tons.

TABLE 9—CENTRES OF PRODUCTION & END USES OF COIR YARN

Type	Producing area	Uses
Wheel-spun		
Anjengo	Paravoor, Nedumganda, Vakkom, Kadakkavoor, Chirayinkeezhu, Anjengo, Perumathura, Azhoor, Kaniapuram, Murukkumpuzha & Panathara	70% exported or utilized as yarn ; 30% for mats & matting
Mangadan	Mangad, Asramom, Kandachira, Perinad, Prakulam, Chavara South, Thevalakara, Kozhivila	85% exported as yarn ; 15% used for ropes, agricultural purposes, etc.
Aratory	Arattupuzha, Mahadevicad, Mangalam, Karuvatta, Chingoli, Pallana & Muthukulam	70% exported as yarn ; 30% used for mats & matting
Ashtamudy or Carruva	Kallada, Mundro Island, Peruman & Chavara	Major portion exported as yarn ; 10-15% used for rope
Parur	Vavakkadu, Chittattukara, Pattonom, Kottapuram, Cranganore, Cherai & Gnarakkal	Chiefly for rope making & agricultural purposes ; 35% exported
MK & SMK Yarn	Kumbalangi Manasseri & Andikadavu	Mainly exported ; small quantity used for rope making
Muppiri	South Travancore & some parts of Malabar	Chiefly for house-hold & agricultural purposes
Vycome or Weaving	Areas in Vycome & Shertallai taluks ; Vechoor, Tanneermukkom, Chengada, Poochakal, Chempu, Thrinayamkandam & Kumbalangi in Cochin	70% exported as yarn ; 25% used for mats & matting ; balance for ropes & agricultural purposes
Hand-spun		
Beach	Muhamma, Peruneermangalam, Mararikulam, Punnapra & Mannadcheri	Used for matting ; small quantity exported
Rope	Mostly in Malabar & parts of Cochin ; main centres Kandassankadavu & Manaloor	90% exported ; limited quantity used for rope
Edavannam	Parur, Cranganore, Vypeen & Chowghat	Chiefly for rope making & agricultural purposes
Beypore	Beypore, Elathur, Quilandy Calicut	Mainly for export ; small quantity used for rope
FU (Fine Unsoaked)	Parappanangadi, Vallikunnu, Kallai, Kozhikode	..
Laccadive	..	..
Alapat	Alunkadavu, Cheriyazheekal, Marthoorkulangara & Alappacuthura	75% exported ; 25% used locally

The total number of spindles in 1955-56 for spinning coir yarn in Kerala State was 30,658 ; of these, 717 were non-working. The district-wise distribution of spindles is given in Table 12. The percentage classification of spindles producing different types of yarn in Travancore-Cochin was as follows: Anjengo, 30 ; Aratory, 13 ; Mangadan, 16 ; Vycome, 19 ; Parur, 5 ; Alapat, 3 ; Ashtamudy, 6 ; and others, 8.

TABLE 10—TYPES & QUALITIES OF COMMERCIAL YARN*

Yarn	Colour	Scorage	Av. diam. *in.*	No. of twists/ft.	No. of yd./lb.	Breaking strength/lb.	Av. pith content	Av moisture content
Anjengo special	1 & 2	11-19	0.102	76	165	27.1	0.87	10.77
Anjengo superior	1 & 2	11-17	0.107	70	142	33.2	0.81	10.09
Anjengo ordinary	1, 2 & 3	9-14	0.125	62	108	39.0	2.04	11.26
Mangadan	1 & 2	11-15	0.129	64	110	37.3	1.06	11.58
Aratory superior	1, 2, 3 & 4	11-17	0.116	60	159	26.8	1.57	10.45
Aratory ordinary	2, 3 & 4	12-16	0.108	55	132	32.2	1.82	10.52
Ashtamudy	1, 2 & 3	11-15	0.128	46	106	47.3	1.66	11.78
Alapat	1 & 5	9-18	0.109	41	138	36.7	1.10	11.43
Vycome	1-5, 7, 8 & 10	11-15	0.111	36	145	35.7	4.77	10.40
Beach	5 & 6	10-14	0.137	33	137	28.4	15.66	10.56
Beypur	1-3	7-9	0.208	26	53	96.6	3.44	12.47
Kollandy	1, 2, 4, 8 & 10	8-12	0.154	32	32	60.6	3.71	11.97
Unsoaked yarn	1 & 3-6	7-13	0.150	29	109	28.7	23.11	12.64

* Rep. Marketing of Coconuts & Coconut Products in India (Manager of Publication, Delhi), 1944, 278.

TABLE 11—PRODUCTION OF SPINDLE-SPUN YARN IN KERALA*

YARN	PRODUCTION tons
Anjengo	16,340
Aratory	6,965
Mangadan	11,632
Vycome	4,920
Parur	7,749
Alapat	515
Ashtamudy	5,444
Other sorts	7,413
TOTAL	60,978

* Rep. Census of Coir Spindles & Industrial Establishments (Coir Board, Ernakulam), 1957, 15.

TABLE 12—NUMBER OF SPINDLES AND WORKERS ENGAGED IN SPINDLE-SPINNING IN KERALA*

DISTRICT	SPINDLES No.	NO. OF WORKERS		
		Self employed	Hired labour	Total
Trivandrum	8,264	7,322	21,503	28,825
Quilon	14,311	22,286	20,403	42,689
Kottayam	2,839	9,191	307	9,498
Trichur	3,717	4,121	7,265	11,386
Malabar	730	413	1,753	2,166

* Rep. Census of Coir Spindles & Industrial Establishments (Coir Board, Ernakulam), 1957, 3 & 8.

Workers Employed

The number of workers self-employed and hired labour engaged in spindle-spinning in Kerala State are given in Table 12.

Assuming that on an average 3 persons are required for beating husks and cleaning and drying fibre required for one spindle, it may be estimated that a total of 1,84,387 persons are engaged in spindle spinning. To this figure has to be added those engaged in spinning coir yarn by hand. It is estimated that approximately 35,000 people are so engaged in the Travancore-Cochin area.

5 Weaving, Dyeing & Printing

By virtue of its cheapness and its wear and damp-resistance qualities, coir is eminently suitable for floor covering. The manufacture of coir mats and mattings was started in 1859 on a small scale by James Darragh, who founded and developed the well-known firm of *Darragh. Smail & Co. Ltd.*, Alleppey.

The mat and matting industry in Kerala is centred mainly around Alleppey, Shertallai, Cochin and Kozhikode. A total of 15,387 workers are engaged in coir industrial establishments in Kerala. Of these 11,735 are skilled, 1,982 semi-skilled and 1,670 unskilled workers. Matting is also manufactured to a small extent in Bengal.

Weaving

Coir yarn as received from spinners is not suitable for weaving for various reasons, such as uneven distribution of thickness, shades, twists, etc. The first process in a weaving factory, therefore, involves the treatment of yarn with a dilute solution of sulphuric acid which improves its colour and gives it a certain amount of brightness. This treatment is particularly necessary for yarns used for the better types of mats. Treated yarn is washed and dried in shade. It is then sorted into different grades having regard to differences in tints (Fig. 5). Hanks of yarn of small lengths are subjected to the "pulling out" process and spliced together into continuous yarns. To make the weaving more convenient and avoid wastage of yarn, balls of different kinds, according to different requirements, are made in the balling machine. Before actual weaving in looms, yarn is subjected to spooling and beaming.

Spooling consists in winding the yarn on a wooden cylindrical drum. The hanks are put on a revolving frame which helps winding around the cylinder as the yarn is brought out by the pull caused by the revolving spool. The spools are then fitted on a frame, known as Creel, at the back of the beaming machine. The strands are then drawn through the Creel box and wound on the drum according to the lengths required.

FIG. 5—SORTING OF COIR YARN

FIG. 6—WEAVING OF COIR MAT

After winding on the drum, the strands are drawn through a reed which keeps the yarn separate from one another and avoids entanglements. The drum is put under tension by means of hanging weights and the yarn from the spool is wound round a central support of iron or wood. The yarn thus wound is known as chain.

Mats and mattings are woven on wooden handlooms similar to those used in cotton weaving, but of stronger build (Fig. 6). Power looms are seldom employed, as due to the coarseness of fibre, the shuttles take only short lengths of yarn and need frequent replacement. Wheel-spun yarn is generally used for warp and hand-spun yarn for weft.

In Holland and Germany and also in U.K. the manufacture of coir mats

and matting is an established industry. Holland is the largest manufacturer of coir floor coverings in the world.

Mats

Depending on the quality of yarn employed and the method of weaving, mats are divided into three main types: Coir, Fibre and Speciality. Each type is further divided into varieties depending on the construction of the mat.

Coir Mats. Beach-Rod is an inexpensive door mat from Beach yarn. It is produced in a large range of attractively stencilled designs, some inlaid with coir fibre and known as Beach-Rod (Inlaid). The mats are bound with braids manufactured from five or seven ends of hard-twist yarn.

Beach-Creel is also made of Beach yarn, but differs from Rod mats in construction. Creel construction is designed to produce an article with low pile. Creel mats are manufactured in a variety of stencilled designs and in some of them jute twine is used for chain.

Beach-Bit is an inexpensive medium weight mat which, however, does not possess the same uniformity of colour as Beach Rod. The mats are bound with braid manufactured from five or seven ends of hard-twist yarn.

Vycome-Rod is a superior variety of mat made out of Vycome yarn. Designs inlaid with coir fibre are also produced.

The construction of Vycome-Creel mats is the same as Beach-Creel mats, but the material used is much superior and the articles produced have clean and light appearance. A stronger variety is manufactured with jute twine for chain.

Creel mats are wrap-piled fabrics. Like fibre mats, loose and tight warps are employed ; the loose warp is carried over a slotted rod to form loops while the texture is woven with the taut warp and weft. The loops are cut into tufts by a knife inserted, face upwards, in a slot of the rod.

Fibre Mats. Fibre mats are made direct from the fibre without being spun into yarn. They are produced in plain natural colour, or in a variety of woven designs and patterns. They have good strength, durability and brushing qualities and are more expensive than ordinary brush floor mats.

The fibre employed is machine cleaned. The process of weaving is more or less the same as that used for woollen carpets. Two warp beams, one above the other, are used and unspun coir is used for piles.

The warp on the lower beam is drawn taut on the loom and is manipulated by two heald frames taking alternate threads. The upper beam carries weighted coiled ropes. Small sheaths of fibre, takes, as they are called, are knotted around strings in the lower layer of the taut warp ; a weft yarn is knocked in and the position of the healed frames changed. The lower layer of the taut warp and the loose warp of the upper beam are woven together, with the weft forming the backing. Designs are woven by using fibre sheaths of various colours. After weaving, the mats are stitched and braided, sheared by machine, and finally trimmed with scissors to give a relief to the pattern.

Speciality Mats. Mats bearing initials, names, monograms, trade marks, etc. and sinnet and corridor mats are classed as speciality mats. They are hard-wearing utility articles produced without brush.

Brush Door Mats (plain, inlaid or fancy) are generally made from inferior yarn, usually Beach yarn ; superior Vycome yarn and imported hard fibre from Ceylon are also used. They are woven on a simple loom in which the warp is tightly drawn and rows of yarn strands (usually 3 or 4) for the pile are inserted through the shed and wound on a grooved iron rod placed over alternate warp ends across the mat. After inserting a single weft through the shed, the sley is beaten fast to allow the weft to get close to the fabric. After changing the shed by treading, a thin knife edge is inserted, face upwards, into the groove and drawn along the whole length of the rod and a complete row of tufts is formed. The process is repeated till the required length is obtained. Three or four weft yarns are then woven to ensure that none of the piles gets out of the mat after it is removed from the loom. Any desired pitch, ranging from 600 to 1,200 tufts per sq. ft., can be produced depending on the fineness of the warp thread and tuft yarn, number of warp threads per foot of loom roller and the closeness of knocking in. Mats are cut to required lengths and stitched with coir braid all round. They are then dried, sheared and trimmed ; they are sometimes bleached and colour designs stencilled.

The design for inlaid mats is traced on ruled papers in which each tuft knot is represented by a square. Wherever the design cuts a row of tufts, the winding of tuft yarn is stopped and yarn of the required colour inserted. The work is slow and demands considerable skill on the part of the weaver.

Sinnet Mats are manufactured from any type of coir yarn, plain or dyed. Anjengo, Beach and Vycome yarns are largely used. Fancy mats are produced from dyed yarn braid and stitched in a variety of attractive combinations.

Corridor Mats are fabricated on a frame. Weft strands are formed by taking them alternatively over metal rods arranged in a series to make the

required length. The rods are removed after the fabric is formed and thick coir yarn is inserted to bind the warp strands together. Corridor mats may be plain or woven in the simple designs.

Mattings

Coir mattings are manufactured from four types of coir yarn, viz. superior Anjengo, superior Aratory, Vycome and Beach. The yarn is wound on bobbins and transferred to a creel. Warping is done between sticks or by means of a peg board, the yarn from the bobbins being passed on to the warping drum and the requisite width prepared by warping the sections on a weaver's beam.

Patterns up to eight treadles are usually woven on ordinary looms ; for designs requiring more than eight treadles, jacquard machines are employed. Weaving is similar to pit-loom weaving without the fly-shuttle arrangement. For close weave, a stick is inserted through the shed and used as a beater before the weft is passed through the shed. The stick is removed and the sley beaten up ; the shed is then changed. The process is repeated till the required length of 45 m. is woven. The matting is removed from the loom and mended to eliminate knots and uneven coloured yarn and projecting warp or weft ends are cut. It is then rolled into bundles of 50 ft. (46 m.) length and 36 in. (0.914 m.) width. Buckling due to uneven tension is prevented by stretching the matting on machines before rolling. Matting is also made in widths of 9 in. (0.23 m.) or multiples of 9 in. up to 72 in. (21.95 m.). Both plain and fancy mattings are available in 50 ft. rolls.

Two-Treadle (Ordinary & Basket Weave). In this type of matting, the strands of coir yarn are interlaced individually in alternate order. Both sides of the matting present the same appearance. This matting is woven by extending the two-treadle weave both vertically and horizontally so that two or more strands of yarn are present in both directions.

Three-Treadle (Twill Weave & Herringbone). The weave causes diagonal lines to be formed in the matting which when spread out gives the twill effect. Points of intersection move outward and upward on succeeding picks. The directions of lines are alternately right and left in the Herring-bone weave. The matting is irreversible.

Four-Treadle. In this type of weave, twill lines are found either diagonally or in opposite directions on both sides of the fabric. The matting is reversible.

Multi-Treadle. This process of weaving on hand-operated multi-needle looms enables the production of intricate patterns, according to buyers' tastes.

Fig. 7—Coir products

Rugs

Mattings are supplied in rug sizes in attractive stencilled patterns. They may be finished with fringe ends, drawn-in ends or bound ends. For finishing into fringe ends, a double row of stitching is affixed approximately two inches from the cut edge. Weft strands between the stitching and the cut are then removed so that the warp strands form a two-inch fringe.

For fixing into drawn-in ends, the weft strands are removed approximately 1½-2 in. from the cut edge and the warp strands doubled back and interlaced in the matting. This form of finishing tends to prevent the corners of the rug from curling.

Bound end finishing is secured by covering the cut-end with jute binding which may be plain or coloured. The binding is sewed to the rug by a double row of stitching.

Mourzouks

Mourzouks are produced in a variety of sizes and patterns. The weaving differs from that of matting. Special cross weaving looms are used and surface and patterns are formed by the weft and not by the warp. On the completion of weaving, warp ends are drawn back into the fabric to give a strong and straight edged finish. The weaving enables the production of intricate geometrical and floral designs. Aloe and jute yarn may be used as warp yarn.

Carpets

Coir carpets are woven on matting looms. Warp strands are varied in thickness and number to produce thick and heavy fabric with a ribbed finish. The required design is secured by inserting coloured weft yarn.

A pilot plant consisting of three mechanized looms for collection of data on the effect of mechanization on the weaving sector is proposed to be set up by the Coir Board.

Dyeing & Printing

Colour and design play an important part in the marketing of coir products. Dyed yarn is exported to Australia for the manufacture of matting.

Acid, acid-mordant, basic substantive and sulphur dyes, and also natural colouring matters like logwood, are employed for dyeing coir fibre. A good number of dyestuffs commonly employed in dyeing cotton are not suitable for coir. The following dyestuffs are commonly used in coir dyeing[21a], the list is not exhaustive: Auramine OS, Chrysoidine YS, Bismarck Brown RLS, Magenta PS, Methylene Blue 2BS, Methyl Violet 2BS, Malachite Green AS Crystals, Jute Black 75512: Naphthalene Orange GS, Naphthalene

TABLE 13—COIR PRODUCTS MANUFACTURED IN INDIA

COIR	MATS		MATTING	RUG	MOURZOUK
	Fibre	Speciality			
Beach-Rod Plain Stencilled Inlaid	Double chain Plain Fancy	Initial Lettered Monogram Trade mark	Two-treadle Ordinary weave Basket weave	Fringed ends	Geometrical
Beach-Creel Plain Stencilled	Triple chain Plain Fancy	Sinnet Plain Fancy	Three-treadle Twill weave Herringbone	Drawn-in ends	Floral
				Bound ends	Combination
Beach-Bit Plain Mottled		Corridor	Four-treadle Reversible	Stencilled	
		Car	Multi-treadle		
Vycome-Rod Plain Inlaid		Golf Tea	Speciality mattings Cricket pitch Billiard surround		
		Gymnasia			
Vycome-Creel Plain Fancy Stencilled		Wrestling			
		Dumping			

TABLE 14—SIZES & SPECIFICATIONS FOR COIR PRODUCTS

	Size* in.	Specification
Mats	No. 0-9: 22 in. × 12 in. 48 in. × 30 in.	Construction†, wt./sq. ft. and pile height
Sinnet		Wt./sq. ft., thickness, and type of yarn
Corridor		Type of weft yarn, scorage and wt./sq. ft.
Mattings	Widths: 18, 22½, 24, 27, 36, 45, 54, 63, 72, 108 in. etc.	Type of yarn for warp & weft, scorage§, weftage△ and weight‡
Mourzouks	30 × 18 ; 48 × 24 ; 54 × 27 ; 90 × 27 66 × 36 ; 72 × 36 ; 72 × 45 ; 72 × 54 90 × 54 ; 108 × 72 ; 108 × 90	Type of yarn for warp and weft, no. of strands/foot of warp and weft, wt./sq. yd.
Rugs	Same as for mourzouks	Same as for mattings Same as for mourzouks

* Size measurements are taken from outside edges on the reverse side of mats (including braid where applicable).
† only for Beach-Rod and Vycome-Rod mats.
△ number of transverse strands of yarn in 12 in. length.
§ number of warp strands in 36 in. width/20
‡ weight of 50 sq. yd. of matting.

TABLE 15—DISTRIBUTION OF MANUFACTURING ESTABLISHMENTS & LOOMS IN 1955*

Place	No. of establishments	No. of looms	
		Mats	Mattings
Trivandrum Dt Chirayinkil taluk	5	1	80
Quilon Dt Quilon taluk	2	...	256
Karunagappathy taluk	2	24	...
Ambalapujha taluk	212	3656	2812
Sherthalai taluk	535	4459	1000
Kottayam Dt Vycome taluk	18	122	135
Trichur Dt Cochin-Kanayannur	18	132	174
Malabar Dt Kozhikode taluk	5	...	31
Total	327	8394	4488

* Rep. Census of Coir Spindles & Industrial Establishments (Coir Board, Ernakulam), 1957, App. V.

Coir Scarlet A, Naphthalene Red JS, Naphthalene Green GS and Coomassie Violet RS.

Fibre loosely packed in sacks may be dyed in open kettles. The material is wetted out by steeping in water for a couple of hours. It is then processed through dyebaths. Efficient circulation of dye liquor throughout the mass is necessary to avoid uneven results. A rotary pump is employed for this purpose when large quantities of fibre are handled. Concentrated solutions of dyes worked to a suitable consistency can be applied to woven and trimmed materials by blocks or through stencils and screens. Pigment colours can also be applied in the form of dispersions in drying oils. The fibre is subjected to prior bleaching treatment if dyeing for bright tones is desired ; bleaching is particularly necessary for imparting light and medium shades[39].

Woven fabric may be printed to produce definite effects. Mechanical methods are employed to apply the colouring materials. Fine designs of intricate configurations cannot be applied owing to the stiff nature of coir fibre and the roughness of coir products. Simple geometrical patterns and floral designs can be printed by employing stencils and screens.

The mats are fixed on a table by means of projecting steel spikes. The dye paste is applied to the material through stencils by a stiff brush ; gum-tragacanth, casein and oil-soluble gum resins are used as thickeners of the paste ; chemicals which help to fix the colour are also incorporated. Dried prints are steamed for fixing. The methods of dyeing and printing have been described by Prabhu.

Prabhu[39] has carried out investigations on dyeing and printing of coir. It is proposed to establish a mechanized dyeing plant in the *Coir Research Institute*.

Production

Table 13 lists the coir products manufactured in India. Standard sizes and specifications of mats and mattings, mourzouks, rugs and carpets are given in Table 14.

Table 15 gives the number of manufacturing establishments and looms in 1955.

6 Ropes & Cordages

Coir is resistant to the action of water and has the property of elongation without breaking. By virtue of these properties, coir has long been used for ropes and cordage. Ropes are produced on a cottage industry scale in Kerala and a few other States ; ropes are produced in Calcutta in mechanized factories.

In the production of ropes by the manual process, two wheels, similar to those used in coir spinning, are employed ; the stationary wheel is provided in the two or more hooks geared together. A number of yarn strings of equal length are taken and the ends tied to individual hooks on the stationary wheel, while the other ends are passed through a grooved rod and tied to a single hook on the movable wheel. Individual strands are twisted by operating the stationary wheel and when sufficient twist is imparted, the movable wheel is turned in the opposite direction and the grooved rod moved forward till it reaches the stationary wheel. The strands are then removed from the hooks and a knot made. The rope is then coiled. Coir ropes range in diameter from 2½ in. to 4 in. and the varieties produced are Nadan, Elathur and Quilandy[49].

Rope making on a factory scale was started in Calcutta in 1780 by *W. H. Harton & Co. Ltd.* Coir ropes are formed in a rope walk, consisting of a bobbin bank, foreboard, traveller and top cart, all in the same line. The bobbin bank contains the yarn. The foreboard has attached to it a register plate with a number of holes through which yarns are drawn to form a strand ; a few hooks, which can be rotated by a gear arrangement, are also provided. The traveller also carries a number of hooks and moves along rails from one end of the walk to the other, drawing and twisting the strands and laying the rope. The top cart, also running on the same rails, carries a top, which is a conical hardwood piece with grooves, for guiding the strands.

The diameter of strands used in rope making is determined by the diameter and construction of the rope. The number of yarns required for a strand

are determined by the strand diameter and the yarn number. Having settled the number of yarns in a strand and the number of strands in a rope, any required size of rope can be made. The twist in the strand and the angle of lay (angle of twist or angle of strands to the centre line) of the rope are important. The lay can either be left- or right-hand and is opposite to the twist in the strands. Yarns are usually given a left-hand twist and strands a right-hand twist. Ropes are made with soft (32-34°), medium (37°), and hard (39-40°) lays.

The required number of yarns are passed from the bobbin bank through the register plate, through a tube, and then attached to a hook in the traveller. As the traveller moves down the walk, the hook revolves drawing out and twisting the yarns into a strand. Several strands can be drawn simultaneously. The number of yarns for forming a strand with a particular rope yarn increases with the rope size (for 24's yarn, the number increases from 11 to 284 for sizes from 2-12 in. circum.). When the required length of the strand is obtained, it is removed and hitched to posts at the side of the walk and further strands are drawn. The top cart is not used during stranding.

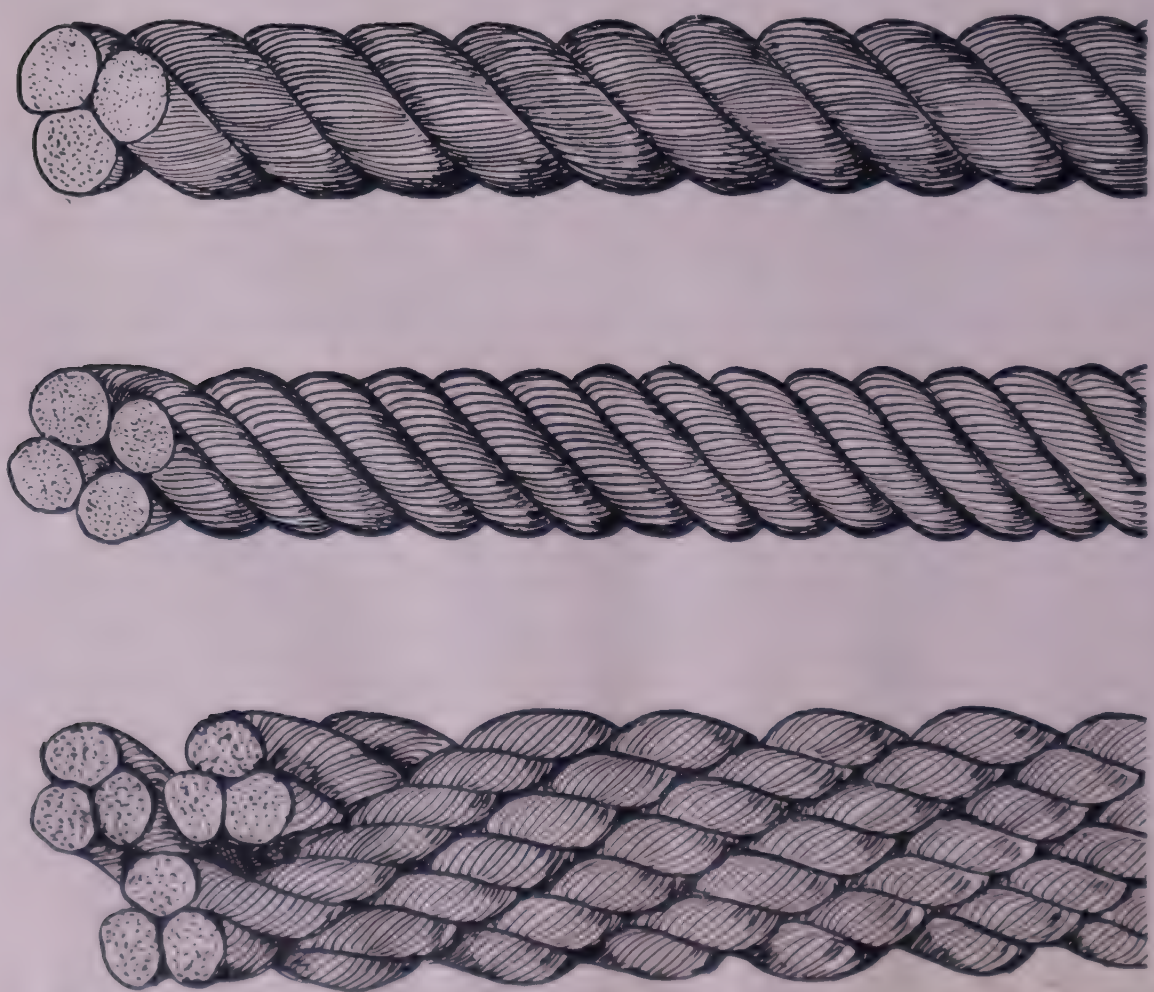


FIG. 8. CONSTRUCTION OF ROPES—HAWSER LAID (TOP); SHROUD LAID (MIDDLE); CABLE LAID (BOTTOM)

Fig. 9—Coir rope

TABLE 16—EXPORTS OF COIR & COIR PRODUCTS FROM INDIA*

	1957		1958	
	Qty *tons*	Value *lakh Rs.*	Qty *tons*	Value *lakh Rs.*
Carpets & floor rugs	3,832	66.4	3,451	59.1
Mats & mattings	14,124	216.8	14,646	227.1
Cordage & ropes	2,274	22.6	2,113	24.1
Fibre	802	7.5	927	7.5
Yarn	54,232	557.1	52,493	499.1
TOTAL	75,265	870.4	73,631	816.9

* Monthly Statistics of the Foreign Trade of India (Department of Commercial Intelligence & Statistics, Calcutta), 1957 & 1958.

In the next operation, the required number of strands for the rope is attached to a single hook in the traveller and to separate hooks in the foreboard. In between, the strands pass through grooves in the top cart. During laying, the hooks in the foreboard impart the correct retaining twist to the strand (in the same direction as in the original strands), while the hook in the traveller gives an opposite twist and lays them into a rope. The lay of the rope is controlled by the speed of the top cart which is moved automatically by the pressure of strands against the smaller end of the top, its speed being controlled by the pressure on a pair of ropes linked round the bar of the top cart and wrapped round the laid ropes.

The ropes are then treated with batching oil. Ropes are supplied in coils of 120 fathoms (720 ft.), unless otherwise specified. They are wrapped in water-proof paper and covered by cloth. Small ropes are supplied in hanks.

Ropes are usually plain or hawser laid. They are made of three strands and are available in all sizes from 1 in. circumference upwards. Four-strand ropes, known as shroud laid ropes, are available in all sizes from $1\frac{1}{2}$ in. circumference upwards ; they are superior to hawser laid ropes as regards roundness. When ropes are made with more than three strands a hollow core is formed in the centre which is filled by a central cord serving as a cushion for covering strands. Cable laid ropes are made from three or more hawser laid ropes formed from soft-laid strands. These are available in sizes from 5 in. circumference upwards ; they have greater elasticity and flexibility than hawser laid ropes of the same circumference but less strength[49] (Fig. 8).

Specifications

Factory-made coir ropes are required to conform to specification G Tex Misc-49 of the Indian Navy and Army. The Indian Standards

Institution has issued three draft specifications for (*i*) hawser laid coir rope [Doc: TDC 14 (332)] ; (*ii*) shroud laid coir rope [TDC 14 (333)] ; and (*iii*) cable laid coir rope [TDC 14 (334)].

Production. Statistics of production of coir ropes and cordages are not available. Some of the mechanical roperies in Calcutta have an output of 1,000 tons. About 2,000 tons valued at nearly Rs. 23 lakhs are annually exported from India (Table 16).

A major portion of the ropes produced in India is consumed by shipping and fishing industries and by the Navy for haulage. Coir ropes are also used in oil well drilling and for power transmission and machine drives. The building and engineering industries utilize considerable quantities of rope. In the farm, it is used for tying cattle, drawing water from wells, etc. In Holland, Belgium, Norway and other countries, fishing nets are made of coir cordage.

7 Other Uses of Coir

The main outlet for coir goods now produced in India is through export. Internal consumption of coir goods has not been very high. Depression in foreign markets in regard to coir goods on account of high cost or competition from other fibres is likely to result in adverse repercussions on Indian production. To offset this eventuality, the exploitation of the non-conventional uses of coir would appear to be of great importance. The Coir Board is seized of this problem.

Besides its main use as floor covering and in rope making, coir fibre finds extensive use as packaging material to protect goods against shock in transport. The common form in which it is used is by making a soft cushion of the mattress fibre between two thicknesses of low quality jute hessian. This pad is manufactured in rolls that can be cut and used[22]. During the World War II this material was in great demand for resilient packing as prescribed in specification DTD 780.

Investigations have been carried out on the utilization of coir fibre for production of activated carbon[33], artificial horse hair[16,45], paper pulp[30], roofing tiles, writing boards, container dishes, thermal insulators, etc. and many of the processes are subjects of Indian and foreign patents[9,47]. Recent work in the Forest Research Institute has shown that high-stretch paper can be made from Coir. Considerable quantity of coir fibre is imported by Italy for manufacturing of olive oil filters.

In Germany coir is rubberized for making cushion seating for automobiles and railways. The rubberization is brought about by splashing layers of coir fibre and rubber with the help of a specialized machine. The possibility of producing similar articles from inferior grades of coir fibre needs investigation.

Coir fibre of inferior quality may be used for manufacturing hard board by mixing with fossil resin, melted at a high temperature and suitably pressing

into boards. Loosened fibre and fresh wet husk can be used for making into boards without the use of resins by hydraulic pressing.

Coir yarn has been found to be the ideal lead for hop vines for taking them to the required height. Hop is a major flavouring agent used in the brewing of beer. There is good demand for coir yarn in U.S.A. for this purpose.

Tea estates in India, especially those in South India, are using bags made out of coir yarn for collecting and transporting fresh tea leaves from the garden to the factory. Coir bags are also used for lifting coal from mines in Bengal, Assam and Central India.

Coir yarn is also used for making fenders which are attached to ships and boats for preventing shock or injury due to collision.

Fabricated as salitahs to pack tentage, bags to pack tent poles and pins and transport articles of bakery and butchery, coir mats were extensively used during the last war.

Coir mats with pile for commercial packaging purposes have come into vogue. Circular brush mats have come into use as cushions instead of protective card-board tubes for packing.

Another interesting development in the use of coir mat is as a construction material in buildings. A process, called Mulvan process, developed by Mulvaney[3] is useful for constructing partition walls of rooms using coir mat as the base on which a mixture of cement and sand is gunnited. It is claimed that this method effects a saving of 15 per cent compared to brick or re-inforced cement concrete work. Besides, the walls are sound-proof and do not crack.

Coir mattings after bituminization offer possibilities of being used as floor coverings in godowns where stored goods are stocked as they withstand moisture adsorption by the stored goods[38].

Rubber backing of coir mats is also an interesting improvement of the ordinary mats as rubber-backed coir mats are sol-proof, sound absorbent and do not scratch polished floor[38].

Heavy matting made out of thick coir rope is being used for transporting gas cylinder.

One of the recent applications of coir rope is its use as a strainer in tube wells in place of wire mesh strainer or filter point as it is called. It is claimed that the coir filter point tube wells have definite advantages over

the wire mesh type which are in common use in that they are more easily constructed, they are cheaper and give higher output[41].

Coir Waste. Large quantities of coir dust are available (*c.* 1½ candies of pith, short fibre and outer skin for every candy of coir yarn produced). Its utilization has been the subject of investigation in India, Ceylon, and Puerto Rico.

The percentage composition of the waste is as follows: Lignin, 33.3 ; water, 20.0 ; pentosans, 10.4 ; potassium (K_2O), 0.9 ; calcium (CaO), 0.4 ; nitrogen, 0.3 ; and phosphorus (P_2O_5), 0.05 per cent[37]. A part of the dust is burnt as fuel. Coir dust or cocopeat may be used as packing, stuffing, and heat-insulating material. It has been used for improving soil drainage and as mulching, rooting, soil conditioning and seed germinating medium. Coir dust has high (82.3 per cent) water-logging capacity. The addition of 2 per cent of dust to sandy soil is claimed to increase the moisture holding capacity by 40 per cent.

Some processes for the utilization of coir waste have been patented in India. The *Central Food Technological Research Institute*, Mysore has developed a process for the production of insulating materials using coir dust and other waste materials. Experiments conducted at the *Central Research Institute*, Trivandrum have shown that the pith, suitably compounded with rubber latex, is effective as heat or insulation material for the commercial transport of fish to distant places. The possibility of producing power gas from coconut dust has been investigated[15]. As coir fibre and coir dust have great resiliency and cushioning properties, their utility as packaging material for protecting goods against shock during transport may be worth investigating. Manufacture of fabricated cement articles and water resistant boards are other suggested uses for waste.

A process for preparing hardboard from coconut husk shorts and coir dust has been described by Hume[31]. The boards are durable, smooth, inherently insect-proof, fire retarding and water-repellent. They may be sawed, nailed, glued and finished into according to requirement. A hardboard plant has been installed at Banjuwani in Indonesia, with a capacity of 1,000 boards per day.

Hardboards of satisfactory strength and properties have been prepared from unretted coconut husk and coir shearing waste[19].

Fibre boards from coconut pith are produced by *Coconut Pith Industries*, Trivandrum.

A process for the manufacture of Coirolite from coir waste has been worked

out under the auspices of the Coir Board at the Department of Chemical Technology, Bombay University, Bombay.

The process consists in incorporating coirwaste with resins and other ingredients by the usual techniques of plastics manufacture. The powder so obtained is hot-pressed to obtain articles of any shape by using appropriate moulds.

Coirolite is a tough and hard material and possesses good strength and electrical resistance. It can be made to acquire different colours, but the choice is limited to a few deep shades, pastel shades being difficult to obtain.

8 Marketing & Trade

Professional retters constitute the main agency for collecting and distributing coconut husks. They own retting areas or take them on lease and collect husks from producers and coconut merchants either directly or through middlemen. Boatmen also play an important part in assembling and distributing coconut husks. They collect and transport husks on their own account or for professional retters from coconut gardens on the banks of canals and rivers. Some coconut merchants and copra manufacturers also collect husks.

The retters generally extract the fibre and sell it as such or after spinning into yarn. They also sell retted husks to villagers in small lots in return for fibre, the price of which is fixed on the basis of current market value. The principal agents for assembling the fibre are the middlemen who purchase fibre from villagers and sell it in the market.

The fibre is generally spun into yarn by producers themselves (working on their own account or for middlemen) but in certain areas of Cochin and Malabar, considerable quantities of fibre are sold as such.

The yarn is generally bartered by small producers for their daily requirements of rice, oil, salt, etc. ; they also sell yarn for cash to petty merchants. The merchants sort out the hanks of yarn purchased by them according to thickness, colour, appearance, etc., and make them into cylindrical bundles, generally weighing one local maund. The length of yarn in each hank and the number of hanks in each bundle are not uniform and are subject to considerable variation. Some yarns are brought to market in the form of hanks without bundling. Some exporting firms have their own agencies to collect yarn from producing areas and to grade and sort them into hanks. Petty merchants sell the yarn to bigger dealers and wholesale merchants, who in turn, send it to the main assembling and distributing centres like Alleppey and Cochin. Yarn is sold in assembling and distributing centres by firms and commission agents on behalf of merchants in producing areas. Commission agents store the yarn in their godowns and

pay advances against the value of stored yarn. They sell yarn after classifying them into types to wholesale merchants, exporters and manufacturers of mats and mattings. The buyers examine the quality of yarn and roughly estimate the moisture at the time of buying ; sometimes, a bundle or about half a candy of yarn is dried in the sun to determine the loss in weight due to moisture. Manufacturers of mats and mattings take the scorage of the yarn also into account while offering a price. Inferior grades are made into *dhols*, each weighing 5 or 7 lb., for transport in cargo boats as broken stowage.

The yarn for export is dried and sorted into grades according to colour, appearance, twist, scorage, etc., made into hanks of 450 yd. each weighing $2\frac{1}{2}$ lb., and hydraulically pressed into bales of 3 cwt.

In order to reduce the number of middlemen in the trade, cooperative organisations are being organised.

Transport. Water transport plays an important part in the movement of coir and coir products. Transport to consuming and distributing centres is by coastal steamers or rail. Country boats carry traffic between ports on the west coast during dry months.

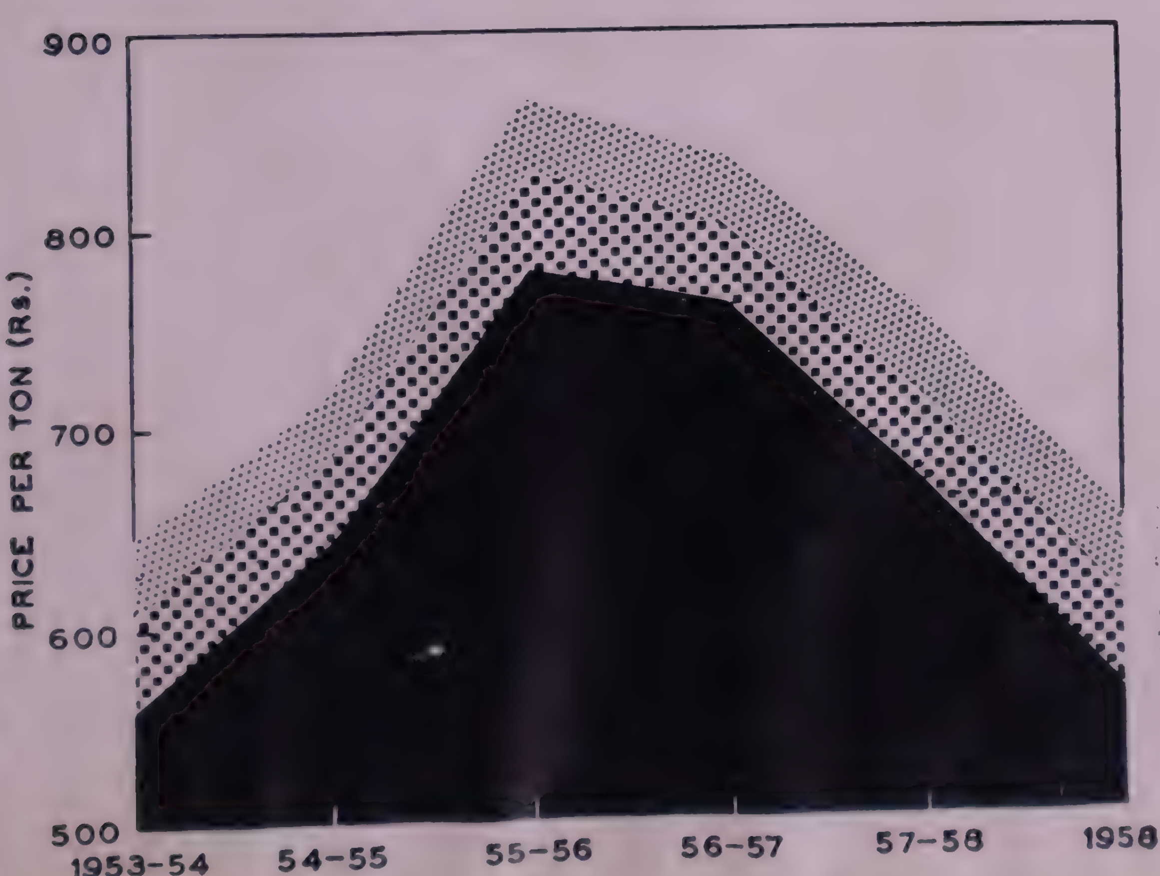


FIG. 10—PRICE TREND OF THREE GRADES OF COIR FIBRE

Prices. The trend of average prices of coir fibre and coir yarn during the periods 1951 to 1958 are given in Fig. 10 & 11. The prices of coir mats, mattings, rugs, carpets, etc. vary widely as they depend upon the quality and size of products. The average price of coir rugs during 1957/58 was Rs. 2.44 per sq. yd. The prices of different varieties of coir rope per 6 cwt. during the year 1957/58 were as follows: Nadan, Rs. 232.69 ; Elathm, Rs. 216.56) ; and Quiland, Rs. 240.24.

Export. Seventy-five per cent of the total export trade in coir products is handled by the *Travancore Coir Mats and Matting Manufacturers' Association,* Alleppey. Coir yarn and mats and mattings are exported from India mainly through Alleppey, Cochin and Malabar coast ports. Small quantities of rope and cordage are also exported. Table 17 gives the quantity of goods exported during the period 1945-1957. The quantity and value of goods exported during 1957 and 1958, are given in Table 16.

Most European countries import coir yarn, the major part (80%) of which is utilized for the production of mattings. The shares of various countries in the import of coir yarn from India during 1958 were: West Germany, 20 ; Netherlands, 15 ; France, 11 ; U.K., 10 ; U.S.A., 9 ; and Italy, 8 per cent.

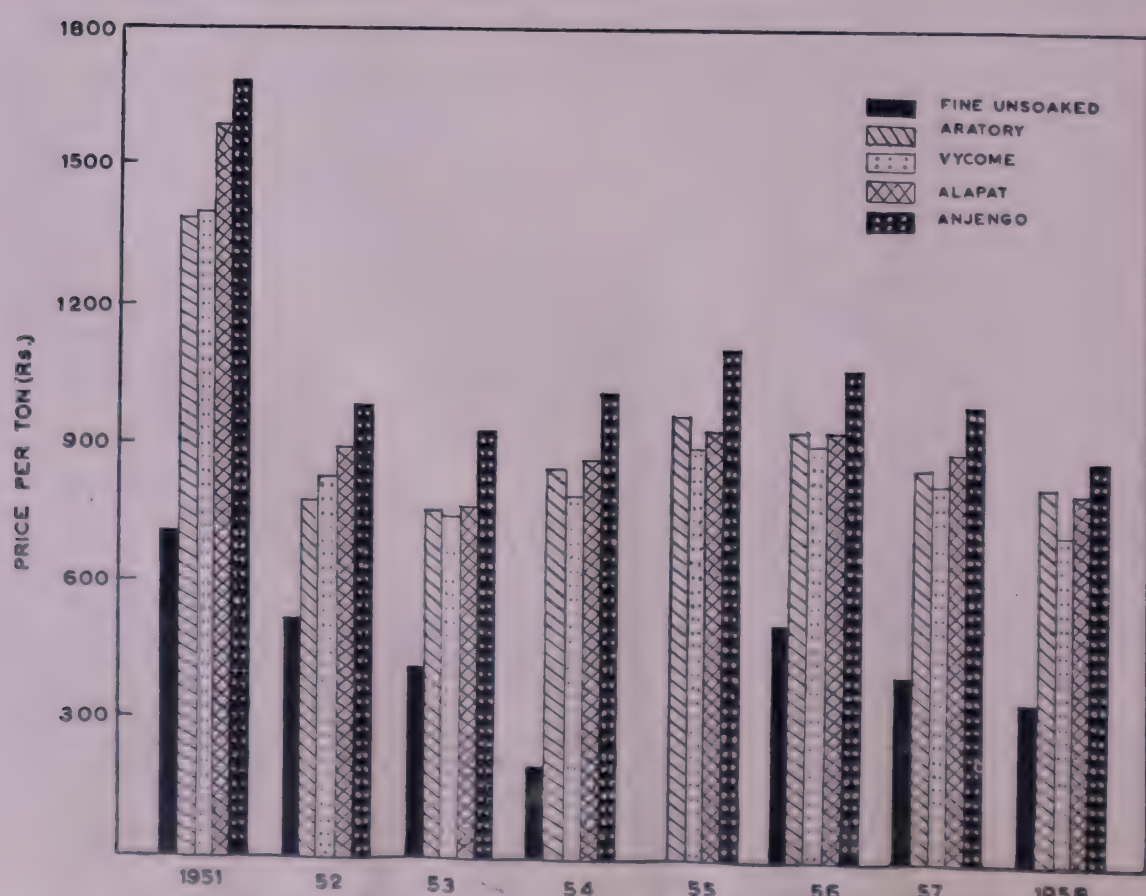


FIG. 11—TREND OF COIR YARN PRICES

TABLE 17—EXPORTS OF COIR & COIR PRODUCTS* (TONS)

	FIBRE	YARN	MATS & MATTINGS	ROPE & CORDAGE
1945/46-1949/50	391	37,194	19,489	756
1950/51	1,011	57,834	22,759	416
1951/52	601	41,768	14,872	537
1952/53	742	48,940	18,224	353
1953/54	674	54,152	22,007	754
1954/55	536	54,421	20,223	864
1955/56	666	54,162	19,400	620†
1956 (April - Dec.)	450	46,404	13,887	17

* Information from Coir Board. Figures for 1954/55-1956 relate to exports from all ports ; figures for other years relate to exports from Alleppey, Cochin, Calicut & other Malabar Coast ports (Department of Commercial Intelligence & Statistics, Calcutta).

† Includes other sorts, e.g. tea leaf bags, coir braids, tent components & patching pieces, coir door curtains, etc.

TABLE 18—DESPATCHES OF FIBRE, YARN & MATTINGS FROM MALABAR PORTS TO PLACES IN INDIA* (TONS)

	FIBRE	YARN	MATS & MATTINGS	ROPE & CORDAGE
1945/46-1949/50	30.3	16,124.0	361.87	3,927.9
1950/51	81.0	14,287.7	39.3	2,967.0
1951/52	118.0	13,584.2	149.15	2,684.7
1952/53	15.0	8,723.0	83.4	2,112.2
1953/54	8.0	9,775.6	3.55	1,800.1
1954/55	...	10,936.2	...	1,883.3
1955/56	...	13,633.0	...	3,125.8
1956/57	...	12,791.4	...	2,504.7
1957/58	174.4	12,586.0	16.1	3,055.2

* Information from Coir Board & Cochin Chamber of Commerce.

The bulk of coir mats and mattings produced in India is exported. The shares of importing countries in the purchase of coir mats and mattings during 1958 were: U.K., 44 ; U.S.A., 16 ; Australia, 8 ; and Denmark, Canada and U.S.S.R., 4 per cent each.

Inland Trade. Considerable quantities of coir yarn are despatched from Alleppey, Cochin, Calicut and other ports on Malabar coast to places within the country.

Table 18 gives the despatches of coir fibre, coir yarn and coir mats and mattings to places in India.

Coir and coir products have been included in the items of commodities under bilateral trade agreements entered into by the Government of India with foreign Governments. Tariff concessions are provided in regard to exports of coir and coir goods to certain countries.

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